Dietary Patterns Associated with Functional Constipation among Japanese Women Aged 18 to 20 Years: A Cross-Sectional Study

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Summary Although several nutrients and foods have been suggested to be preventive for constipation, all previous studies have examined a single nutrient or food in each analysis. In contrast, analysis of dietary patterns may provide new insights into the influence of diet on functional constipation. We conducted a cross-sectional examination of the association between dietary pattern and functional constipation in 3,770 Japanese female dietetic course students aged 18–20 y from 53 institutions in Japan. Diet was assessed with a validated self-administered diet history questionnaire with 148 food items, from which 30 food groups were created and entered into a factor analysis. Functional constipation was defined using the Rome I criteria, which has previously been used in several epidemiologic studies on constipation. The prevalence of functional constipation was 26.0% (n=979). Four dietary patterns were identified: 1) "Healthy," 2) "Japanese traditional," 3) "Western," and 4) "Coffee and dairy products." After adjustment for several confounding factors, the "Japanese traditional" pattern, characterized by a high intake of rice, miso soup, and soy products and a low intake of bread and confectionaries, was associated with a significantly lower prevalence of functional constipation. In comparison with the lowest quintile, the multivariate adjusted odds ratio (95% confidence interval) was 0.52 (0.41–0.66) in the highest quintile (p for trend $<$0.0001). Other dietary patterns were not associated with functional constipation. The Japanese traditional dietary pattern, characterized by a high intake of rice and a low intake of bread and confectionaries, may be beneficial in preventing functional constipation in young Japanese women.
Key Words food-based dietary pattern, factor analysis, functional constipation, Japanese traditional dietary pattern, young Japanese women

Constipation is a common public health problem (*1–4*) with a well-recognized propensity to cause considerable discomfort and affect quality of life (*1*). Regarding nutritional approaches, although much attention has been focused on the benefit of dietary fiber (*5–10*), results to date have been inconsistent. Magnesium (*10*) and water from foods (*10*) have recently been postulated as preventive factors. For foods, various studies have observed associations between the prevalence of constipation and dairy products (*11*), beans (*11, 12*), meats (*11*), fruits (*11*), vegetables (*11*), rice (*3, 9, 12, 13*), eggs (*13*), confectionaries (*9, 12*), and some nonalcoholic beverages (*3, 5, 9, 11*). Nevertheless, the dominant approach of examining single nutrients or foods might not adequately account for complicated interactions and cumulative effects, which might in turn result in the drawing of erroneous associations between dietary factors and disease.

To overcome this limitation, the dietary pattern approach, or the measurement of overall diet, is now widely used to elucidate the relationship between diet and disease (*14, 15*). To our knowledge, however, no previous study has investigated the relationship between dietary pattern and prevalence of constipation. In addition, although the research standard or the definition of functional constipation includes various symptoms such as infrequency, straining, hard stools, and incomplete evacuation (Roma I criteria) (*16*), most previous studies have defined constipation according to the infrequency of bowel movement only (*5–8*) or the subjective perception of the patient (*9, 11*).

Here, we attempted to identify dietary patterns using factor analysis, and examined the relationships between dietary pattern and the prevalence of functional constipation as defined according to the Rome I criteria (*16*) among Japanese women aged 18 to 20 y.

SUBJECTS AND METHODS

Subjects and study design. The subjects were students newly enrolled in the dietetic course at 54 universities, colleges, and technical schools in Japan in April

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2005 (n=4,679). The study design, data-collection method, and study member list have been described in detail elsewhere (*10, 12*). In brief, two kinds of questionnaire on dietary habits and other lifestyle items during the preceding month were completed during an orientation session or first lecture given to freshman, in most institutions within 2 wk after the course began. A third questionnaire on lifestyle during the previous 6 y (i.e., junior and senior high school) was answered in similar fashion, in most institutions within 4 wk after the course began. A total of 4,286 students (4,066 women and 220 men) answered all three questionnaires (response rate=91.6%).

All questionnaires were checked at least once each by staff at the respective institution and at the survey center. Most surveys were completed by May 2005. The study protocol was approved by the Ethics Committee of the National Institute of Health and Nutrition.

Dietary assessment and food grouping. We used a self-administered diet history questionnaire (DHQ), a validated 16-page questionnaire which assesses dietary habits in the preceding 1-mo period (*17, 18*). A detailed description of the questionnaire, calculation of food and nutrient intakes, and validity is given elsewhere (*17, 18*). Measures of dietary intake for 148 food and beverage items and energy were calculated using an ad hoc computer algorithm for the DHQ, which was based on the Standard Tables of Food Composition in Japan (*19*). Information on dietary supplements and data from the open-ended questionnaire items were not used in the calculation of dietary intake.

To reduce the complexity of the data, food items were grouped together (*20*). The grouping scheme was generally based on the principles of similarity of nutrient profiles or culinary usage of the foods, mainly according to the Food Composition Tables of Japanese foods, 5th Revised Edition (*19*), and the classification of food groups used by the National Nutrition Survey (*21*). Finally, 30 separate food groups were established and used in analyses of dietary patterns (*20*).

Definition of constipation. A constipation questionnaire developed for a previous study (*2*) was incorporated into the 20-page questionnaire for lifestyle during the preceding 6 y. We used the definition of functional constipation recommended by an international workshop on the management of constipation (Rome I criteria) (*16*). Although the Rome I criteria were modified in 1999 (Rome II criteria) (*22*), epidemiologic studies have consistently shown that the latter may be too restrictive for the diagnosis of constipation (*2, 4*), and we therefore used the former. The following four questions were used to assess Rome I-defined functional constipation: 1) Do you strain during a bowel movement?; 2) Do you feel a sensation of incomplete emptying after a bowel movement?; 3) How often are your stools hard?; and 4) How many bowel movements do you usually have each week? These questions referred to the last 12 mo. For questions 1–3, four answers were offered: never, sometimes (<25% of the time), often (>25% of the time), and always. Functional constipation was defined as meeting two or more of the four criteria [an answer of often or always to questions 1–3 and less than three bowel movements per week for question 4].

Measurement of confounding factors. In the questionnaires, subjects reported body weight and height, residential area, current smoking (yes/no), and oral medication usage (yes/no). Body mass index (BMI) was calculated as body weight (kg) divided by the square of body height (m^2). Reported residential areas were grouped into six categories (Hokkaido and Tohoku; Kanto; Hokuriku and Tokai; Kinki; Chugoku and Shikoku; and Kyushu) based on the regional blocks used in the National Nutrition Survey in Japan (*21*). Residential areas were also grouped into three categories according to population size (city with population ≥1 million; city with population <1 million; and town and village). Physical activity level was calculated by dividing total energy expenditure by basal metabolic rate calculated using the FAO/WHO/UNU formula (*23*). The calculation method has been described in detail elsewhere (*10, 12*).

Statistical analysis. For the current analysis, we selected female subjects aged 18–20 y (n=3,967). Of these, 197 women were excluded for the following reasons: attendance at an institution which conducted the survey at the end of May (n=97); reported daily energy intake outside the range of 3.7–4.7 MJ (725–3,235 kcal) (*24*) (n=78); or missing information on the variables used (n=24). Thus, 3,770 women underwent final analysis. Further exclusion of subjects with intentional dietary change during the preceding year (n=615) or those habitually using oral laxatives (n=367) did not materially alter the findings, and these subjects were therefore included in the analysis.

Factor analysis (principal component) was conducted to derive the food pattern based on the 30 food groups from the DHQ using the FACTOR PROCEDURE of the SAS software (*25*). Intake of these food groups was adjusted for total energy intake using the residual method (*26*). The factors were rotated by orthogonal transformation (Varimax rotation function in SAS) to achieve a simpler structure with greater interpretability. To identify the number of factors to be retained, we used the eigenvalue >1.0 criterion, the most widely used in factor analysis, as a first step. However, this procedure created 11 independent factors, a number too large for further analyses. The scree plot showed small breaks in the eigenvalues after factor five, suggesting that retaining three or four factors would be optimal. Post-rotated factor loadings revealed that four factors well described distinctive dietary patterns of the study population. After Varimax rotation, factor scores were saved from the principal component analysis for each individual. The factor scores for each pattern and for each individual were determined by summing the intake of each food group weighted by the factor loading (*27*).

The scores were divided into quintiles, and used for comparison with nutrient intake and other lifestyle factors and to estimate associations with the prevalence of

Table 1. Subject characteristics (n=3,770).[a]

Variable	
Age (y)	18.1±0.33
Body height (cm)	157.9±5.3
Body weight (kg)	52.3±7.6
Body mass index (kg/m^2)	21.0±2.8
<18.5	550 (15)
18.5–24.9	2,937 (78)
≥25	283 (8)
Residential block	
Hokkaido and Tohoku	372 (10)
Kanto	1,290 (34)
Hokuriku and Tokai	526 (14)
Kinki	756 (20)
Chugoku and Shikoku	416 (11)
Kyushu	410 (11)
Size of residential area	
City with population ≥1 million	736 (20)
City with population <1 million	2,458 (65)
Town and village	576 (15)
Current smoking	
No	3,716 (99)
Yes	54 (1)
Oral medication usage	
No	3,403 (90)
Yes	367 (10)
Energy intake (MJ/d)	7.6±2.0
Physical activity level	1.40±0.17
Functional constipation[b]	
No	2,791 (74)
Yes	979 (26)

[a] Values are expressed as means±SD or numbers of subjects (%).
[b] Defined according to the Rome I criteria (*14*).

Table 2. Factor-loading matrix for the four dietary patterns (n=3,770).[a,b]

	Factor 1 Healthy	Factor 2 Japanese traditional	Factor 3 Western	Factor 4 Coffee and dairy products
Green and dark yellow vegetables	0.73	—	—	—
White vegetables	0.71	—	—	—
Mushrooms	0.62	—	—	—
Seaweeds	0.55	—	—	—
Soy products	0.50	0.36	—	—
Fish and shellfish	0.49	—	—	—
Potatoes	0.49	—	—	—
Processed fish	0.44	—	—	—
Fruit	0.41	—	—	—
Salted vegetables	0.31	—	—	—
Tea	—	—	—	—
Nuts	—	—	—	—
Rice	—	0.77	—	—
Miso soup	—	0.47	—	—
Fruit and vegetable juices	—	—	—	—
Alcohol	—	—	—	—
Noodles	—	—	—	—
Breads	—	−0.60	—	—
Confectionaries	—	−0.70	−0.33	—
Fats and oils	—	—	0.60	—
Meats	—	—	0.58	—
Seasonings	—	—	0.51	—
Processed meats	—	—	0.46	—
Eggs	—	—	0.33	—
Butter	—	—	—	—
Sugary foods	—	—	—	0.70
Coffee	—	—	—	0.69
Dairy products	—	—	—	0.41
Soup	—	—	—	—
Soft drinks	—	—	—	—
Percentage of variance	10.8%	6.9%	6.1%	5.3%

[a] Data from the self-administered diet history questionnaire (DHQ).
[b] Absolute values <0.27 were excluded from the table for simplicity.

functional constipation. Correlation coefficients for each factor and energy-adjusted nutrient intake were calculated. In logistic regression analysis, we calculated both crude and multivariate-adjusted odds ratios (ORs) and 95% confidence intervals (CIs) for functional constipation for each quintile category of dietary pattern using logistic regression analysis. Multivariate-adjusted ORs were calculated by adjusting for BMI (three categories), residential block (six categories), size of residential area (three categories), current smoking (two categories), oral medication usage (two categories), physical activity level (quintiles), and energy intake (quintiles). We tested for linear trends across categories of dietary patterns by assigning scores to the levels of the independent variables.

All statistical analyses were performed using version 8.2 of the SAS software package (SAS Institute, Inc., Cary, North Carolina, USA). A two-sided p value of <0.05 was considered significant, except in correlation analyses between dietary patterns and nutrient intakes because these were not necessarily independent of each other. A Pearson correlation coefficient of >0.2 or <−0.2 was considered significant.

RESULTS

Subject characteristics are shown in Table 1. A total of 979 women (26%) were classified with functional constipation.

The factor loading matrix is shown in Table 2. High positive loadings indicate strong associations between given food groups and patterns, whereas negative loadings indicate negative associations. Patterns were labeled according to those food groups with high loadings. Factor 1, which loaded heavily on green and white vegetables, mushrooms, seaweeds, soy products, fish and shellfish, potatoes, and fruit, was labeled the "Healthy" pattern. Factor 2, with high loadings for rice, miso soup and soy products was labeled the "Japanese traditional" pattern. Factor 3, with high loadings for fats and oils, meat, processed meat, eggs, and seasoning was labeled the "Western" pattern. Factor 4, with high loadings for sugary foods, coffee, and dairy products was labeled the "Coffee and dairy products" pattern. The four dietary patterns overall accounted for 29.1%

Table 3. Sample characteristics for the lowest (Q1) and highest (Q5) quintiles of four dietary patterns (n=3,770).[a,b]

	Factor 1 Healthy		Factor 2 Japanese traditional		Factor 3 Western		Factor 4 Coffee and dairy products	
	Q1 (n=754)	Q5 (n=754)	Q1 (n=754)	Q5 (n=754)	Q1 (n=754)	Q5 (n=754)	Q1 (n=754)	Q5 (n=754)
Age (y)[c]	18.1±0.3	18.1±0.3	18.1±0.4	18.1±0.4	18.1±0.3	18.1±0.3	18.1±0.3	18.1±0.4*
Body height (cm)	157.9±5.4	158.0±5.4	158.2±5.3	157.7±5.2	158.4±5.2	157.7±5.4	157.9±5.3	157.8±5.1
Body weight (kg)	52.8±7.9	52.1±7.5	52.1±7.4	52.8±7.8	52.0±7.3	52.6±7.9	52.5±7.8	52.1±7.2
Size of residential area								
City with population ≥1 million	144 (19)	162 (22)	176 (23)	145 (19)	152 (20)	161 (21)	148 (20)	174 (23)
City with population <1 million	484 (64)	465 (62)	497 (66)	475 (63)	496 (66)	476 (63)	487 (65)	470 (62)
Town and village	126 (17)	127 (17)	81 (11)	134 (18)	106 (14)	117 (16)	119 (16)	110 (15)
Current smoker	19 (3)	2 (0)	18 (2)	6 (1)	9 (1)	16 (2)	14 (2)	10 (1)
Oral medication usage	47 (6)	107 (14)	85 (11)	82 (11)	99 (13)	72 (10)	65 (9)	95 (13)
Energy intake (MJ/d)[c]	8.0±2.0	8.2±2.00	8.2±2.2	7.8±2.0**	8.1±2.1	8.3±2.1*	8.1±2.1	8.2±2.1
Physical activity level[c]	1.40±0.18	1.43±0.19**	1.42±0.19	1.41±0.17	1.42±0.20	1.41±0.18	1.41±0.19	1.40±0.15

[a]The factors were standardized continuous variables, and each subject had a score for each factor.
[b]Values are expressed as means±SD or numbers of subjects (%).
[c]Significantly different from the first quintile (Q1) of each dietary pattern, *$p<0.05$, **$p<0.001$ (Dunnett's t-test).

of variance in food intake.

The subjects were divided into quintiles by the factor score of each dietary pattern. Sample means and frequencies were calculated across quintiles. Sample characteristics of young women in the lowest and highest quintiles of each food pattern are presented in Table 3. Subjects with a high intake of the Healthy pattern were physically active, while those with a high intake of the Japanese traditional pattern had a high BMI, low energy intake, and were more likely to live in a small town. Subjects with a high intake of the Western pattern had a high BMI and high energy intake.

Correlation coefficients between each of the four dietary patterns and energy-adjusted nutrient intakes are presented in Table 4. For energy-adjusted nutrient intake, the Healthy pattern was correlated with protein, vitamin A, vitamin C, calcium, potassium, magnesium, soluble dietary fiber, insoluble dietary fiber, total dietary fiber, water from foods, water from fluid, and water from all foods (Pearson correlation coefficient (r)=0.22–0.82). The Japanese traditional pattern was positively correlated with carbohydrate, magnesium, and water from foods (r=0.21–0.37), and negatively with fat (r=−0.34). The Western pattern was positively correlated with fat and protein (r=0.31–0.64), and negatively with carbohydrate, and soluble and total dietary fibers (r=−0.68–−0.21). The Coffee and dairy products pattern was positively correlated with calcium, potassium, and magnesium (r=0.27–0.44).

Multivariate-adjusted odds ratios for functional constipation across quintiles of all four dietary patterns are presented in Table 5. There was a clear dose-response relationship between a high intake of the Japanese traditional pattern and a decreased prevalence of constipation. In comparison with the first quintile of the Japanese traditional pattern, multivariate-adjusted odds ratios for women in the second, third, fourth and fifth quintiles were 0.77 (95% CI: 0.62–0.96), 0.74 (95% CI: 0.59–0.92), 0.66 (95% CI: 0.52–0.83), and 0.52 (95% CI: 0.41–0.66), respectively (p for trend <0.0001). No association with prevalence of functional constipation was seen for the other dietary patterns.

DISCUSSION

To our knowledge, this is the first study on the association between dietary pattern and the prevalence of functional constipation. The Japanese traditional pattern showed a strongly negative correlation with the prevalence of functional constipation.

Although constipation is a common condition in several communities, a precise determination of prevalence is not always easy owing to inconsistency among symptoms (*2*, *28*, *29*). In the present study, we used the standard definition of functional constipation recommended by an international workshop on the management of constipation (Rome I criteria) (*16*) to assess functional constipation from various symptoms. The prevalence of functional constipation defined by the Roma I criteria in this population was 26%. A similar

Table 4. Pearson correlation coefficients between each of the four dietary patterns and daily nutrient intakes (n=3,770).[a,b]

	Factor 1 Healthy	Factor 2 Japanese traditional	Factor 3 Western	Factor 4 Coffee and dairy products
Protein (g/d)	0.56	0.12	0.31	0.09
Fat (g/d)	0.09	−0.34	0.64	0.15
Carbohydrate (g/d)	−0.19	0.23	−0.68	−0.12
Vitamin A (mg/d)	0.49	0.08	0.06	0.17
Vitamin C (mg/d)	0.68	−0.01	−0.01	0.07
Calcium (mg/d)	0.42	0.09	−0.16	0.44
Potassium (mg/d)	0.77	0.10	0.00	0.33
Magnesium (mg/d)	0.67	0.21	−0.08	0.27
Soluble dietary fiber (g/d)	0.71	−0.20	−0.20	0.19
Insoluble dietary fiber (g/d)	0.82	0.04	−0.20	0.18
Total dietary fiber (g/d)	0.82	−0.03	−0.21	0.18
Water from foods (g/d)	0.79	0.37	0.04	0.07
Water from fluid (g/d)	0.22	−0.02	0.01	0.08
Total water (g/d)	0.41	0.08	0.02	0.11
Alcohol (g/d)	−0.05	−0.08	0.02	−0.02

[a] All nutrients were energy-adjusted using the residual method.
[b] Pearson correlation coefficients of >0.2 or <−0.2 were considered significant.

Table 5. Multivariate adjusted odds ratios and 95% confidence intervals for functional constipation by quintile (n=754 for each quintile) of each dietary pattern (n=3,770).[a]

	Quintile category of dietary pattern					p for trend
	1 (lowest) (referent)	2	3	4	5 (highest)	
Factor 1 (Healthy)						
n with functional constipation	214	177	186	190	212	
Non-adjusted OR (95% CI)	1.00	0.77 (0.61–0.98)	0.83 (0.66–1.04)	0.85 (0.68–1.07)	0.99 (0.79–1.24)	0.81
Multivariable adjusted OR (95% CI)[b]	1.00	0.75 (0.59–0.95)	0.81 (0.64–1.02)	0.83 (0.66–1.05)	0.93 (0.74–1.17)	0.79
Factor 2 (Japanese traditional)						
n with functional constipation	246	203	197	180	153	
Non-adjusted OR (95% CI)	1.00	0.76 (0.61–0.95)	0.73 (0.59–0.91)	0.65 (0.52–0.81)	0.53 (0.42–0.66)	<0.0001
Multivariable adjusted OR (95% CI)[b]	1.00	0.77 (0.62–0.96)	0.74 (0.59–0.92)	0.66 (0.52–0.83)	0.52 (0.41–0.66)	<0.0001
Factor 3 (Western)						
n with functional constipation	206	183	198	183	209	
Non-adjusted OR (95% CI)	1.00	0.85 (0.68–1.07)	0.95 (0.75–1.19)	0.85 (0.68–1.07)	1.02 (0.81–1.28)	0.87
Multivariable adjusted OR (95% CI)[b]	1.00	0.87 (0.69–1.10)	0.98 (0.78–1.24)	0.90 (0.71–1.14)	1.06 (0.84–1.33)	0.59
Factor 4 (Coffee and dairy products)						
n with functional constipation	201	166	216	200	196	
Non-adjusted OR (95% CI)	1.00	0.77 (0.61–0.98)	1.11 (0.89–1.38)	0.99 (0.79–1.25)	0.97 (0.77–1.22)	0.53
Multivariable adjusted OR (95% CI)[b]	1.00	0.76 (0.60–0.97)	1.09 (0.87–1.37)	0.98 (0.78–1.24)	0.92 (0.73–1.16)	0.80

[a] Functional constipation was defined according to the Rome I criteria (*14*).
[b] Adjusted for body mass index (<18.5, 18.5–24.9, and ≥25 kg/m^2), residential block (Hokkaido and Tohoku; Kanto; Hokuriku and Tokai; Kinki; Chugoku and Shikoku; and Kyushu), size of residential area (city with population ≥1 million; city with population <1 million; and town and village), current smoking (yes or no), oral medication usage (yes or no), physical activity level (quintile), and energy intake (quintile).

prevalence according to these criteria has been observed in Canadian women, at 21% (*4*), and in Spanish women, at 29% (*2*). In contrast, the lower ratio of 15% was reported for elderly Singaporean women (*3*).

At the food level, beneficial effects on constipation have been reported for dairy products such as cheese and milk (*11*), beans (*11, 12*), fruits and vegetables (*11*), meats (*11*), rice (*3, 9, 12, 13*), eggs (*13*), coffee (*11*), Chinese tea (*3, 9*), and Japanese tea (*9*), although the results have not always been consistent. Among these results, however, the favorable effect of rice on constipation has been consistently reported in those studies conducted in Asian countries, where rice is a staple food (*3, 9, 12, 13*). In the previous studies, the prevalence of constipation significantly negatively and positively associated with the intakes of rice and confectionaries, respectively (*9, 12*). The highest loadings in the Japanese traditional pattern were given to rice and confectionaries, positively and negatively, respectively (Table 2). Therefore, the observed strong association between the Japanese traditional dietary pattern and prevalence of constipation is probably explained mainly by these two foods.

With regard to individual nutrients, a protective effect has been seen for a high intake of dietary fiber in some studies (*5, 6*), but not in others, including ours (*7–10*). In contrast, the Healthy pattern, which was highly and positively associated with soluble, insoluble, and total dietary fibers, was not correlated with the prevalence of constipation. Our previous study using the same database showed a weak but significant negative association between the intake of magnesium and water from food and the prevalence of constipation (*10*). The Japanese traditional dietary pattern showed a positive association with the intakes of magnesium and water from foods (Table 4). These variables may therefore at least partly contribute to the lower prevalence of constipation. However, these two nutrients were associated with the Healthy dietary pattern much more strongly than with the Japanese traditional dietary pattern (Table 4). It may indicate the existence of unidentified nutrients or bioactive substances related to the prevalence of constipation in the Japanese traditional dietary pattern.

Our study has several limitations. First, the subjects were not randomly sampled from the general Japanese population, but were rather selected female students aged 18–20 y who might be highly health-conscious. To minimize the possible bias induced by nutritional education, we finished the survey within 1 mo of entrance to the course. Second, our findings came from a cross-sectional study. Because we could not exclude the possibility that the subjects changed their dietary behavior or food choices because of their condition of constipation, it was not possible to evaluate the causal association between dietary pattern and constipation. Third, Rome I criteria do not completely differentiate constipation-predominant irritable bowel syndrome from functional constipation (*28*). This might make the results obscure. Fourth, dietary habits and constipation were evaluated in different time periods, namely in the previous month for the former and in the previous year for the latter. However, the results did not materially change when analysis was limited to subjects reporting a stable diet within the previous year (n=3,155). Fifth, the validity and reproducibility of the dietary pattern identified in this study are unknown. However, the four patterns may be representative of Japanese populations because the same patterns were identified in our previous study among premenopausal Japanese farmwomen aged 40 to 55 y (*20*).

In conclusion, dietary pattern was associated with the prevalence of functional constipation among Japanese women aged 18 to 20 y. The Japanese traditional dietary pattern, characterized by a high intake of rice, miso soup, and soy products and a low intake of breads and confectionaries, may contribute to the prevention of functional constipation. Confirmation requires further studies using various populations with different dietary patterns.

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